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NUTRITIONAL EVALUATION OF SOME EDIBLE UNDERGROUND PLANT PARTS USED BY THE TRIBAL PEOPLE OF SOUTH ODISHA, INDIA

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ABSTRACT

The paper deals with the nutrient analysis of eleven edible underground plant parts of South Odisha, India, most of which are used by the tribal/ rural people at the time of food scarcity. The nutritive value such as crude protein, total sugar, total lipid, vitamin B_1 and vitamin C content of the selected edible underground plant parts were analysed. The plants with edible underground parts collected for nutritional analysis are *Amorphophallus paeoniifolius* (Dennst.) Nicolson (*Amorphophallus campanulatus* Decne.), *Colocasia esculenta* (L.) Schott, *Curcuma angustifolia* Roxb., *Dioscorea alata* L., *D. oppositifolia* L., *D. wallichii* Hook. f. (bulbil and rhizome), *Musa* × *paradisiaca* L., *Nelumbo nucifera* Gaertn., *Nymphaea nouchali* Burm. f., *Raphanus raphanistrum* subsp. *sativus* (L.) Domin (*Raphanus sativus* L.).

Keywords: Edible underground plant parts, nutritive value, South Odisha, tribal people.

INTRODUCTION

With ever-increasing population pressure and fast depletion of natural resources, it has become extremely important to diversify the present day agriculture in order to meet various human needs (Janardhanan & al., 2003). The observed interest in search for alternative food and feed ingredients is of importance, mainly for two reasons, one is the low production of food grains and another is the stiff competition between man and the livestock industry for existing food and feed materials (Siddhuraju & al., 2000).

In developing nations, numerous types of edible wild plants are exploited as source of food to provide supplementary nutrition to the inhabitants. Recent studies on agro-pastoral societies in Africa indicate that these plant resources play a significant role in nutrition, food security and income generation (Edmonds & Chweya, 1995). Furthermore, according to the Food and Agricultural Organization (FAO) report, at least one billion people are thought to use wild food in their diet (Barlingame, 2000). In India, Malaysia and Thailand, about 150 wild plant species have been identified as sources of emergency food (Nesamvuni & al., 2001).

Primitive humans ate all types of fruits, leaves and roots of plants collecting from wild, before he learnt to grow useful plants. The ethnic people use a wide variety of wild plants and plant products as their food. India is one of the largest concentrations of tribal population in the world. The forest plays a vital role in the economy as well as daily needs of the tribal people. In times of scarcity when the staple food is in short of supply tribal people collect many types of wild roots and tubers to supplement their food requirement (Vidyarthi, 1987).

Attempts have been made by some researchers from different parts of the world on compositional evaluation and functional properties of various types of edible plants (Bello & al., 2008; Olaiya & Adebisi, 2009; Ali, 2010; Mohan & Kalidass, 2010; Ali, 2011; Shajeela & al., 2011; Aregheore, 2012; Afolabi & al., 2012; Adeniyi & al., 2012; Polycarp & al., 2012; Chandra & al., 2012; Chandra & Mishra, 2014; Deshmukh & Rathod, 2014; Deshmukh, S. & Rathod, 2014). In India, some researchers also enumerated nutritional evaluation of various types of edible plants (Dahot, 1993; Pandey & al., 2006; Nazarudeen, 2010; Seal, 2012; Jain & Tiwari, 2012; Yadav & al., 2014). However, work on nutritional composition of wild edible tuberous plants available in Odisha is scanty. Nutrient analysis of wild edible plants plays a crucial role in assessing their nutritional significance (Pandey & al., 2006). The considerable use of wild edible tuberous species by the local people in their diet motivated us to carry out the present nutrients analysis. Therefore, an attempt has been made to determine the nutritional composition of some of the selected wild edible tuberous plants of South Odisha.

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MATERIALS AND METHODS

Sample preparation

Out of 30 districts of Odisha, South Odisha consists of seven districts. Thirty-seven wild edible tuberous plant parts that include tubers, roots, rhizome, bulb and bulbils were collected by the tribal people in different seasons, as per their availability, from different parts of South Odisha (Misra & Misra, 2014).

Plant specimens with edible underground parts collected from different localities during different seasons were dried and poisoned with saturated mercuric chloride solution with ethyl alcohol (Jain & Rao, 1977). The specimens were identified with the help of local floras (Haines, 1921-1925; Gamble 1915-1936; Saxena & Brahmam, 1994-1996; Misra & al., 2009, Misra and Panda, 2014) and the voucher specimens were deposited in the Herbarium of the Department of Botany, Berhampur University (BOTB), Odisha, India.

The samples collected for nutritional analysis are *Amorphophallus paeoniifolius* (Dennst.) Nicolson (*Amorphophallus campanulatus* Decne.) (Araceae); *Colocasia esculenta* (L.) Schott (Araceae); *Curcuma angustifolia* Roxb. (Zingiberaceae); *Dioscorea alata* L. (Dioscoreaceae); *D. oppositifolia* L. (Dioscoreaceae); *D. wallichii* Hook. f. (bulbil and rhizome) (Dioscoreaceae); *Musa × paradisiaca* L. (Musaceae); *Nelumbo nucifera* Gaertn. (Nymphaeaceae); *Nymphaea nouchali* Burm. f., (Nymphaeaceae); *Raphanus raphanistrum* subsp. *sativus* (L.) Domin (*Raphanus sativus* L.) (Brassicaceae).

For each sample about one gram of fresh sample (tubers, roots, rhizome, bulb, and bulbils) was taken and washed thoroughly with distilled water for analysis. Three replicates were taken for each sample.

Chemical analysis:

Moisture content

Moisture content of the selected fresh underground samples were determined by keeping the sample in a hot air oven at 70 °C to a constant weight and expressed in percentage.

Crude protein

Crude protein content of selected plants with edible underground parts was determined by Bradford method (Sawhney & Singh, 2006).

The sample was macerated with 0.1 M phosphate buffer solution and after centrifugation at 8000 rpm for 30 minutes the supernatant was taken and added with 20 % TCA and again centrifuged. The pellet was dissolved in 0.1 N NaOH and mixed well and centrifuged. Then to the supernatant Bradford reagent was added and optical density was recorded in the Equip-Tronic digital Spectrophotometer (Model No EQ-825) at 595 nm against blank solution. The crude protein content of the sample was determined from the standard graph.

Total sugar

For extraction of total sugar anthrone reagent test was applied (Sawhney & Singh, 2006).

Finely ground sample added with 80% hot alcohol was centrifuged at 8000 rpm for 10 minutes and the process was repeated 5-6 times till the supernatant was free of sugar as judge by a negative test with anthrone reagent. The residue was cooled in ice water and was added with 52 % perchloric acid and again centrifuged. The extract was added with anthrone reagent and the absorbance was taken in the Equip-Tronic digital Spectrophotometer (Model No EQ-825) at 630 nm against blank solution. The total sugar content was estimated from the standard graph.

Total lipid

For extraction of total lipid, chloroform methanol mixture (2:1 vol) test was applied. (Sawhney & Singh, 2006).

Plant sample was grinded in presence of anhydrous sodium sulphate in a mortar and was added with chloroform-methanol mixture and was transferred to an air tight glass stopper iodometric flask. The content of the flask was shaken in a mechanical shaker for 1 h and was filtered in a glass sintered funnel. The solvent from the residue was removed by distilling under vacuum. Since the residue left after drying contain crude lipid, the residue was again extracted with chloroform-methanol mixture containing 1% NaCl. The collected pooled fraction was taken in a separatory funnel, shaken thoroughly and was allowed to stand for 5 minutes. The total lipid content would be recovered in the lower chloroform layer that was drained out in a beaker and the upper layer was treated again with 5-10 ml of chloroform-methanol mixture for 3-4 times to extract any residual lipid left. The solvent was evaporated by keeping the beaker in a warm water bath with a constant blowing of a slow stream of nitrogen gas over the surface then the total lipid was determined.

Ascorbic acid (vitamin C)

Visual titration method based on reduction of 2, 6-dichlorophenol indophenols dye was adopted for estimation of ascorbic acid (vitamin C) content (Sawhney & Singh, 2006).

The sample was crushed thoroughly with 0.4% oxalic acid for 5 minutes and filterted through two layer of cheese cloth and was centrifuged at 1000 rpm for 20 minutes. The final volume was made to 5 ml with oxalic acid, which was pipetted in a white porcelain dish and titrated against the standardized indophenols reagent until the solution becomes pink which should persist for at least 15 seconds. The ascorbic acid content of the extract was calculated by the formula

I x S x D/A x 100/W= mg of Ascorbic acid

Where, I= ml of indophenols reagent used in titration, S= mg of ascorbic acid reacting with 1 ml of the reagent, D= volume of the extract in ml, A= the aliquot titrated in ml, W= the weight of the sample in g.

Thiamine (vitamin B_1)

Photofluorometric method using oxidising agent (potassium ferricyanide) was adopted for quantitative determination of thiamine (vitamin B_1) content of fresh underground sample (Sawhney & Singh, 2006).

The sample was grinded with 0.1N sulphuric acid then centrifuge at 4000 rpm for 20 minutes; the supernatant fraction was decanted and the residue was again extracted with 10 ml of the acid and then the final volume of the collected supernatant fraction was made into 50 ml with 0.1 N sulphuric acid. Potassium ferricyanide reagent was added to a suitable portion of thiamine extract followed by 15% sodium hydroxide then the content was shaken. To it iso-butanol was added and allowed to stand till the two phases separated out completely. The lower aqueous layer was discarded and the traces of water from the upper organic layer were removed by adding a small amount of solid anhydrous sodium sulphate. Graded volume of standard solution containing 0-5 microgram of thiamine hydrochloride were pipetted out. The fluorescence intensity of the standard and the given sample were measured using a primary filter of 365 nm and a secondary filter of 435 nm in a Systronics Photofluorometer (Model 152). The amount of thiamine in the given sample was determined from the standard curve.

Three determinations were carried out for each analysis. The mean values and standard deviations were calculated using statistical software.

RESULTS

Plant species selected for nutritional analysis are listed with botanical name, Odia name and the estimated value of various nutritional compounds observed in 11 edible tuberous plant parts are shown in Table 1.

Moisture content

From the experimental result, it is observed that all the selected fresh wild tubers analyzed registered much moisture content with a maximum of 78.6% in *Raphanus raphanistrum* and minimum of 69% in *Nymphaea nouchali* (red flower). However, *Amorphophallus paeoniifolius* (77.3%), *Musa* × *paradisiaca* (73.3%), *Nelumbo nucifera* (73.3%) *Colocasia esculenta* (72.3%), *Dioscorea oppositifolia* (71.6%) *D. wallichii* (bulbil) (71.6%), are richer in moisture content than the other species such as *Dioscorea wallichii* (rhizome) (70.6%), *Dioscorea alata* (69.6%) and *Curcuma angustifolia* (68.6%).

Crude protein

Among the 11 edible tuberous plants studied, *Colocasia esculenta* contains the highest crude protein (32.92 mg g^{-1}) followed by *Dioscorea oppositifolia* (29.44 mg g^{-1}). *Curcuma angustifolia* and *Dioscorea wallichii* (bulbil) each contains 25 mg protein g^{-1} tissue. *Amorphophallus paeoniifolius, Dioscorea alata, Dioscorea wallichi* (rhizome) exhibited protein content between 11 and 19 mg g^{-1}. Less than 10 mg g^{-1} crude protein content was showed by *Raphanus raphanistrum* (8.16 mg g^{-1}), *Musa × paradisiaca* (5.24 mg g^{-1}) and *Nymphaea nouchali* (red flower) (3.87 mg g^{-1}). *Nelumbo nucifera* had the lowest protein content (1.38 mg g^{-1}) (Table 1).

Total sugar

All the selected edible tuberous plants analysed showed high amount of total sugar content. *Dioscorea wallichii* (rhizome) (520.5 mg g^{-1}) had the highest total sugar content followed by *Nymphaea nouchali* (red flower) (435.2 mg g^{-1}), *Dioscorea oppositifolia* (308.50 mg g^{1}), *Dioscorea wallichii* (bulbil) (286.7 mg g^{-1}), *Colocasia esculenta* (222.85 mg g^{-1}) and *Dioscorea alata* (211.2 mg g^{-1}). *Amorphophallus paeoniifolius* (184.5 mg g^{-1}), *Musa × paradisiaca* (131.12 mg g^{-1}) *Nelumbo nucifera* (114.47 mg g^{-1}) and *Curcuma angustifolia* (105.17 mg g^{-1}) showed lower sugar content. *Raphanus raphanistrum* (34.16 mg g^{-1}) exhibited the lowest value (Table 1).

Total lipid

Among the edible tuberous plants studied, *Nelumbo nucifera* showed the highest total lipid content (0.008 mg g^{-1}) while *Amorphophallus paeoniifolius, Dioscorea alata* and *Raphanus raphanistrum* exhibited the lowest total lipid content (0.001 mg g^{-1}). *Dioscorea wallichii* (bulbil) (0.007 mg g^{-1}), *Dioscorea oppositifolia* (0.006 mg g^{-1}), *Nymphaea nouchali* (red flower) (0.006 mg g^{-1}), *Curcuma angustifolia* (0.003 mg

Table 1 : Crude protein, total sugar, fat and vitamin B_1 and C content of some of the selected tuberous plants of South Odisha, India. Mean±Standard deviation.

Plant Name	Odia Name	Moisture (%)	Crude Protein (mg g^{-1})	Total Sugar (mg g^{-1})	Total lipid (mg g^{-1})	Vitamin B_1 (mg g^{-1})	Vitamin C (mg g^{-1})
Amorphophallus paeoniifolius (tuber)	*Olua*	77.3 ±22.6	11.1 ±1.26	184.5 ±0.79	0.001 ±0.0006	0.0006 ±0.0001	Nil
Colocasia esculenta (tuber)	*Saru*	72.3 ±27.6	32.92 ±0.39	222.85 ±0.58	0.002 ±0.001	0.0007 ±0.0001	Nil
Curcuma angustifolia (rhizome)	*Palu kanda*	68.6 ±39.3	25.40 ±0.56	105.17 ±1.04	0.003 ±0.002	Nil	Nil
Dioscorea alata (tuber)	*Khamb alu*	69.6 ±30.3	12.8 ±0.76	211.17 ±1.26	0.001 ±0.0006	Nil	Nil
Dioscorea oppositifolia (tuber)	*Pithala kanda*	71.6 ±28.3	29.44 ±0.59	308.50 ±1.80	0.006 ±0.003	Nil	Nil
Dioscorea wallichii (bulbil)	*Phala kanda*	71.6 ±28.3	25.75 ±0.25	286.67 ±1.5	0.007 ±0.004	Nil	Nil
Dioscorea wallichii (rhizome)	*Phala kanda*	70.6 ±29.3	18.71 ±0.75	520.5 ±0.76	0.002 ±0.001	Nil	Nil
Musa × paradisiaca (rhizome)	*Kadali kanda*	73.3 ±16.6	5.24 ±0.25	131.12 ±0.95	0.003 ±0.005	Nil	Nil
Nymphaea nouchali (red flower)	*Ranga-kain*	69.0 ±27.6	3.87 ±0.14	435.17 ±1.04	0.006 ±0.004	Nil	Nil
Nelumbo nucifera (rhizome)	*Padma*	73.3 ±26.6	1.38 ±0.18	114.47 ±0.85	0.008 ±0.005	0.0007 ±0.0001	0.24 ±0.02
Raphanus raphanistrum (rhizome)	*Mula*	78.6 ±21.3	8.16 ±1.04	34.16 ±1.25	0.001 ±0.0006	0.0006 ±0.0001	0.16 ±0.02

g^{-1}), *Musa × paradisiaca* (0.003 mg g^{-1}), *Dioscorea wallichii* (rhizome) (0.002 mg g^{-1}), exhibited moderate total lipid content (Table 1).

Vitamins

Among the 11 edible tubers, most of them did not exhibit appreciable amount of vitamin B_1 and vitamin C contents. Only edible underground part of *Nelumbo nucifera* showed vitamin B_1 (0.0007 mg g^{-1}) and vitamin C (0.24 mg g^{-1}) and *Raphanus raphanistrum* showed 0.0006 mg g^{-1} vitamin B_1 and 0.16 mg g^{-1} vitamin C. The tuberous plant *Amorphophallus paeoniifolius* and *Colocasia esculenta* showed 0.0006 mg g^{-1} and 0.0007 mg g^{-1} vitamin B_1 content, respectively (Table 1).

DISCUSSION

The results obtained in this study show a close agreement with those reported by Gopalan & al. (1982**)** in terms of moisture, crude protein, total sugar, total lipid, vitamin B_1 and vitamin C content. Out of the selected plants, *Dioscorea alata*, *D. oppositifolia, D. wallichii* (bulbil and rhizome) and *Colocasia esculenta* showed a close agreement with the findings of Mohan & Kalidass (2010) and Chandra & Mishra (2014) in terms of moisture, crude protein, and total lipid content.

The present crud protein content of the tuber of *Colocasia esculenta* (3.29%) is more than the report (3.0%) made by Gopalan & al. (1982) and is less than the value (4.3%) reported by Mohan & Kalidass (2010). Protein content of the tuber of *Dioscorea alata* (1.28 %) is lower than the earlier reported value (2.81%, Chandra & Mishra, 2014 and 1.3 % in Gopalan & al., 1982) and the protein content of tuber of *D. oppositifolia* (2.94%) is less than the earlier report (7%; Mohan & Kalidass, 2010). The protein content of tuber of *Amorphophallus paeoniifolius* (1.1%) and *Nymphaea nouchali* (red flower) (0.3%) are less than the earlier report (1.2%, 0.4%) made by Gopalan & al. (1982). The tuber of *Raphanus raphanistrum* (0.8%) shows higher protein content than the earlier report (0.7%, Gopalan & al. 1982).

The total sugar content of tuber of *Colocasia esculenta* (18%) is less than the value (21.1%) reported by Gopalan & al. (1982) but more than the value (7.7%) made by Mohan & Kalidass (2010). *Dioscorea alata* contains more sugar (21.1%) than the reported values (18.1%, Gopalan & al., 1982 and 6.80%, Chandra & Mishra, 2014). Present sugar value of *Amorphophallus paeoniifolius* (18.4%) is similar with the earlier report (18.4%, Gopalan & al., 1982). Total sugar value of *Nymphaea nouchali* (43.5%) is more than the earlier report (43%) made by Gopalan & al. (1982). But the total sugar content of tuber of *Dioscorea oppositifolia* (30.8%) is more than that of earlier reports (7.4%, Mohan & Kalidass , 2010).

The total lipid (0.001 mg g^{-1}) content is lower than that of earlier report (0.003 mg g^{-1}, Chandra & Mishra, 2014). Tuber of *Colocasia esculenta* contained lower total lipid value than the reported value (0.006 mg g^{-1}, Mohan & Kalidass, 2010) but similar with the value (0.002 mg g^{-1}) reported by Gopalan & al., 1982. The total lipid content of *Dioscorea oppositifolia* (0.006 mg g^{-1}) shows close agreement with the earlier report (0.006 mg g^{-1}) made by Mohan & Kalidass, 2010. Total lipid value of *Amorphophallus paeoniifolius* (0.001 mg g^{-1}) is same as the earlier report (0.001 mg g^{-1}) made by Gopalan & al. (1982).

Vitamin B_1 content of tuber of *A. paeoniifolius* (0.0006 mg g^{-1}) is higher than the earlier report (0.0002 mg g^{-1}, Gopalan & al., 1982). Vitamin C content (0.16 mg g^{-1}) of *Raphanus raphanistrum* is also higher than the earlier report (0.15 mg g^{-1}, Gopalan & al., 1982).

Some of the differences in the nutritional values compared to other reported value may be due to factors such as climate, species, and nature of soil, growing conditions, application of natural or artificial manure and the period of analysis. All the selected edible tuberous plants have high percentage of moisture content. However, rhizome of *Nelumbo nucifera* showed the highest moisture content. All the selected edible tuberous plants reported in this study contain little amount of crude protein (0.1 to 3.2%), with the highest value in *Colocasia esculenta,* which indicates that these vegetables can be used as food for building and repairing of body tissues. In the present study, especially the *Dioscorea* species (*D. alata*, *D. oppositifolia, D. wallichii* (bulbil and rhizome) seem to be contained some amount of crude protein (1.2 to 2.9%). It had been reported that the *Dioscorea* species composed of mainly starch with some amount of crude protein, lipid and vitamins (Lasztity & al., 1998). In the present study, the rhizome of *Dioscorea wallichii* showed the highest estimated total sugar content followed by other species which indicate that it plays a key role in central metabolic pathway of the body. They also provide stored form of energy as glycogen in liver and muscles (Hassan & Umar, 2006). It had been reported that approximately 600 *Dioscorea* species were eaten in various parts of the globe (Agbor-Egbe & Treche, 1995), they contained rich amount of total sugar (starchy tubers) and suggested to have nutritional superiority when compared with other tropical root crops (Coursey, 1967). Among the studied plants, highest total lipid content was shown by *Nelumbo nucifera* that plays an important role in the human body help in brain function, joint mobilization and even energy production (Saidu & Jideobi, 2009).

The result of vitamin analysis showed that vitamin B_1 and vitamin C contents were poor in most of the selected edible underground parts. It had been reported that most of the tuberous plants contain little amount of vitamin B_1 and vitamin C (Gopalan & al., 1982).

Vitamin B_1 content of tuber of *Nelumbo nucifera, colocasia esculenta* is higher than other species, which suggest that it plays an important role in metabolising glucose in the body (Olaiya & Adebisi, 2009). Only *Nelumbo nucifera* and *Raphanus raphanistrum* showed higher vitamin C than the earlier report (Gopalan & al., 1982), which indicates that vitamin C is a powerful antioxidant is vital for the body performance (Okwu, 2004).

Besides their usage as food, these plants are also exploited for their medicinal properties. Most of these species are utilised against various disease by the local communities through their indigenous knowledge. For example, in the present study *Dioscorea alata,* taken as edible tuberous plant, the boiled tuber is useful in leprosy piles and gonorrhoea (Das & Ramakant, 1988). The tubers are also believed to possess activities such as antimicrobial, antioxidant, anti-cough, anti-diabetic, anti-diarrhoea, and anti-cancer activity (Shui & Leong, 2002). *Dioscorea alata* tuber contains diosgenin, which is widely used as a precursor in the synthesis of steroid hormones such as progesterone, corticosteroids, and anabolic steroids (Chandra & Mishra, 2014). Rhizome of *Nymphaea nouchali* used to cure tumours (Biswas & Ahmed, 1987). The corms of *Amorphophallus paeoniifolius* are acrid, astringent, irritant, anti-inflammatory, carminative, and digestive, they are useful in elephantiasis, tumors, inflammations, haemorrhoids, haemorrhages, vomiting, cough, bronchitis, asthma, anorexia, dyspepsia, flatulence, colic, constipation, seminal weakness, fatigue, anemia and general debility (Nair, 1993). The rhizome of *Curcuma angustifolia* used in folk medicine as stimulant, digestive, stomachic and therefore the rhizome is not only culinary but also medicinal to increase the digestibility of the cooked food (Misra & al., 2014).

CONCLUSION

On the basis of nutritional evaluation of the edible underground plant parts consumed by the tribal people of South Odisha it can be concluded that most of them are a good source of crude protein, total sugar and total lipid. The study further emphasizes upon medicinal property of the tuberous plants not restrict to treat disease but also improve overall health due to their nutrient content. Consumption of these edible plants could provide several health benefits and are recommended for pharmacological analysis. It is, therefore, suggested that these valuable edible underground plant parts should not be ignored rather can be used as a good alternative source of food to alleviate hunger and malnutrition.

These food plants are neglected and underutilized due to lack of awareness, little research attention, poor commercialization and deficient policy frameworks for harnessing their actual potential in tribal/rural communities. Thus public awareness and community based programmes through joint forest management plan need to be encouraged at all levels for *ex situ* and *in situ* conservation of such species of future potential to enhance the food security of tribal communities of South Odisha.

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भारत के दक्षिणी उड़ीसा के आदिवासियों द्वारा प्रयुक्त कुछ भूमिगत भोज्य पौधांशों का पौष्टिकता मूल्यांकन

शिवांगिनी मिश्रा एवं मलय कुमार मिश्रा

सार सारांश

भारत के दक्षिणी उड़ीसा के 11 भूमिगत भोज्य पौधांशों से संबंधित अभिलेख जो पौषकीय तत्व से संबंधित हैं, ग्रामीण आदिवासियों द्वारा खाद्य संकट के समय प्रायः उपयोग किये जाते हैं। चुनिन्दा भूमिगत भोज्य पौधांशों के पौष्टिक तत्वों उदाहरणनार्थ अपरिष्कृत प्रोटीन, पूर्ण शर्करा, पूर्ण विटामिन बी एवं विटामिन सी का विश्लेषण किया गया है। पौष्टिकता संबंधी विश्लेषण हेतु भूमिगत भोज्य पौधांश संग्रह किए गए हैं, उनमें *एमोरफोफेलस पियोनीफोलियस* (डेनेस) *निकॉलसन* (एमोरफोफेलस) (केम्पेनुलेट्स डेकने) *कोलोकेसिया एसकुलेंटा* (लिनियस) स्कॉट. *कुर्कुमा अंगुष्टिफोलिया* रक्सबर्ग, *डायसकोरिया आलाटा* लिनि., *डायसकोरिया आपोजीटीफोलिया* लिनि., *डायसकोरिया वालिचाई.* हुक एफ (गुल बिल एवं राइजोम), *मुसा पेराडिसियाका* लिन., *निलम्बो न्यूसिफेरा* गर्टन, *निन्फिया नौचली* बर्म एफ रेफेनस, *रेफेनिसट्रम* उपजाति *सटाइवस* (लिनि.) डॉमिन, *रैफेनस स्टाइवस.* लिनि, आदि हैं।